SnapShot: The Nuclear Envelope II

Andrea Rothballer and Ulrike Kutay
Institute of Biochemistry, ETH Zurich, 8093 Zurich, Switzerland

Cell

		H. sapiens	*D. melanogaster*		*C. elegans*	*S. pombe*		*S. cerevisiae*
Cytoplasmic filaments		RanBP2 (Nup358)	Nup358	CG11856	NPP-9	–	–	–
Cytoplasmic ring and associated factors		Nup214 (CAN)	DNup214	CG3820	NPP-14	Nup146	SPAC23D3.06c	Nup159
		Nup88	Nup88 (Mbo)	CG6819	–	Nup82	SPBC13A2.02	Nup82
		GLE1	GLE1	CG14749	–	Gle1	SPBC31E1.05	Gle1
		hCG1 (NUP2L1, NLP-1)	tbd	CG18789	–	Amo1	SPBC15D4.10c	Nup42 (Rip1)
Nup 98 complex		Nup98	Nup98	CG10198	Npp-10N	Nup189N	SPAC1486.05	Nup145N, Nup100, Nup116
		RAE1 (GLE2)	Rae1	CG9862	NPP-17	Rae1	SPBC16A3.05	Gle2 (Nup40)
Outer NPC scaffold (Nup107-160 complex)		Nup160	Nup160	CG4738	NPP-6	Nup120	SPBC3B9.16c	Nup120
		Nup133	Nup133	CG6958	NPP-15	Nup132, Nup131	SPAC1805.04, SPBP35G2.06c	Nup133
		Nup107	Nup107	CG6743	NPP-5	Nup107	SPBC428.01c	Nup84
		Nup96	Nup96	CG10198	NPP-10C	Nup189C	SPAC1486.05	Nup145C
		Nup85 (PCNT1)	Nup75	CG5733	NPP-2	Nup-85	SPBC17G9.04c	Nup85
		Seh1	Nup44A	CG8722	NPP-18	Seh1	SPAC15F9.02	Seh1
		Sec13	Sec13	CG6773	Npp-20	Sec13	SPBC215.15	Sec13
		Nup37	tbd	CG11875	–	tbd	SPAC4F10.18	–
		Nup43	Nup43	CG7671	C09G9.2	–	–	–
		Centrin-2[1]	tbd	CG17493[1], CG31802[1]	R08D7.5[1]	Cdc31[1]	SPCC1682.04	Cdc31[1]
Central NPC scaffold (Nup53-93 complex)		Nup205	tbd	CG11943	NPP-3	Nup186	SPCC290.03c	Nup192
		Nup188	tbd	CG8771	–	Nup184	SPAP27G11.10c	Nup188
		Nup155	Nup154	CG4579	NPP-8	tbd	SPAC890.06	Nup170, Nup157
		Nup93	tbd	CG7262	NPP-13	Nup97, Npp106	SPCC1620.11, SPCC1739.14	Nic96
		Nup53(Nup35, MP44)	tbd	CG6540	NPP-19	Nup40	SPAC19E9.01c	Nup53, Nup59
Nup62 complex		Nup62	Nup62	CG6251	NPP-11	Nsp1	SPAC26A3.15c	Nsp1
		Nup58/Nup45[2]	Nup58	CG7360	NPP-4	Nup45	SPAC22G7.09c	Nup49
		Nup54	Nup54	CG8831	NPP-1	Nup44	SOBC19G7.15	Nup57
Nuclear ring and associated factors		Nup153	Nup153	CG4453	NPP-7	Nup124	SPAC30D11.04c	Nup1[3]
		Nup50	Nup50	CG2158	NPP-16	Nup61	SPCC18B5.07c	Nup2
		–	–	–	–	Nup60	SPCC285.13c	Nup60
Nuclear basket		TPR	Mtor	CG8274	NPP-21	Nup211	SPCC162.08c	Mlp1, Mlp2
Transmembrane nucleoporins		NDC1	Ndc1	CG5857	NPP-22	Cut11	SPAC24C9.01	Ndc1
		POM121	–	–	–	–	–	–
		GP210	Gp210	CG7897	NPP-12	–	–	–
		TMEM33	Kr-h2	CG9159	Y37D8A.17	Tts1	SPBC1539.04	Pom33
		–	–	–	–	Po152	SPBC29A10.07	Pom152
		–	–	–	–	Mug31	SPAC1002.02	Pom34
Other nucleoporins		ELYS	Elys homolog	CG14215	MEL-28	–	–	–
		Aladin (AAAS)	tbd	CG16892	–	–	–	–
			tbd	CG13137				
Lamins[4]	A-type	Lamin-A Lamin-C Lamin-C2 Lamin-AΔ10	Lamin-C (pG-IF)	CG10119	–	–	–	–
	B-type	Lamin-B1 Lamin-B2 Lamin-B3	Lamin Dm0	CG6944	Lamin-1 (Ce-lamin, CeLam-1)	–	–	–
SUN domain proteins		SUN1 (UNC84A) SUN2 (UNC84B, Rab51P) SUN3 (SUNC1) SPAG4 (SUN4) SUN5 (SPAG4L, TSARG4)	Klaroid Giacomo	CG18584 CG6589	UNC-84 SUN-1(Matefin)	Sad1	SPBC12D12.01	Mps3 (Nep98)
KASH domain proteins		Nesprin-1[5] (Syne-1, Enaptin) Nesprin-2[5] (Syne-2, Nuance) Nesprin-3 Nesprin-4	MSP-300 Klarsicht	CG18251 CG17046	ANC-1 ZYG-12 UNC-83 KDP-1	Kms1 Kms2	SPAC3A11.05c SPBC947.12	Mps2 Csm4
LEM/HeH domain proteins[6,7]	Group 1	Emerin LAP2[8] LEMD1 (CT50, LEMP-1)	Otefin Bocksbeutel tbd	CG5581 CG9424 CG3748	Emerin homolog 1 (Ce-emerin)	–	–	–
	Group 2	LEMD2 (LEM2, NET25) MAN1 (LEMD3)	MAN1	CG3167	LEM-2 (Ce-MAN1)	Mug61 (Man1) Lem2	SPAC14C4.05c SPAC18G6.10	Src1 (Heh1) Heh2
	Group 3	Ankle1 (LEM3, ANKRD41) Ankle2 (LEM4)	tbd tbd	CG8679 CG8465	LEM-3 Y55F3BR.8 (LEM-4L)	–	–	–

See online version for legend and references.

SnapShot: The Nuclear Envelope II

Andrea Rothballer and Ulrike Kutay
Institute of Biochemistry, ETH Zurich, 8093 Zurich, Switzerland

The table depicts nucleoporins, lamins, LINC complex constituents, and LEM/HeH domain proteins across selected eukaryotic model organisms.

For the well-characterized nuclear envelope proteins in *H. sapiens* and *S. cerevisiae*, homologs in *D. melanogaster* (protein, ORF), *C. elegans* (protein or ORF), and *S. pombe* (protein, ORF) were listed based on literature, blast similarity, and database searches (http://blast.ncbi.nlm.nih.gov; http://www.uniprot.org; https://portal.biobase-international.com). Alternative protein names are given in parentheses. *tbd* indicates that a protein name has not yet been defined. Nups with FG domains are highlighted in red text.

For nucleoporins, homologs across species are depicted. SUN, KASH, and LEM domain proteins are listed without direct homology assignment across species. Family members were defined by presence of the respective conserved domains. Membrane topology and domain conservation were verified for all membrane proteins (http://www.cbs.dtu.dk/services/TMHMM; http://www.ebi.ac.uk/interpro). Note that nuclear envelope localization has not been demonstrated for all of the listed homologs.

Footnotes

[1]Centrin-2 is part of the mammalian Nup107-160 complex, whereas budding yeast Cdc31 is part of the NPC-associated THSC/TREX-2 complex. NPC association of the listed fly, worm, and fission yeast centrin sequence homologs has not been reported.
[2]Nup45 is a splice variant of Nup58.
[3]Homology to Nup153 is limited to the FG domain.
[4]Human A-type lamins are encoded by LMNA gene. Isoforms derive by alternative splicing and proteolytic processing (Lamin-A). Lamin-B1 is encoded by LMNB1 gene. Lamin-B2 and Lamin-B3 are alternative splice isoforms both encoded by LMNB2 gene.
[5]Nesprin-1 and -2 exist in many isoforms. Giant isoforms contain an actin-binding domain, spectrin repeats, and a KASH domain. Smaller isoforms lack the actin-binding domain. Isoforms lacking the KASH domain have also been described.
[6]Metazoan proteins contain a LEM domain, which binds to DNA via BAF. Yeast proteins contain the related HeH domain, which directly binds to DNA.
[7]LEM/HeH domain proteins are divided into three groups. Group 1 proteins contain one TM domain (type II) and the LEM/HeH domain. Group 2 proteins contain two TM domains (type II), the LEM/HeH domain, and an MSC domain. Group 3 proteins contain no TM domain, the LEM/HeH domain, and Ankyrin repeats. Note that one TM domain (type I) was predicted for Ankle2 (http://www.cbs.dtu.dk/services/TMHMM) and that no LEM domain was found in Y55F3BR.8 and CG8465 (http://www.ebi.ac.uk/interpro).
[8]LAP2 exists in isoforms α, β, δ, ε, γ, and ζ, of which α lacks the TM domain.

REFERENCES

Brachner, A., and Foisner, R. (2011). Evolvement of LEM proteins as chromatin tethers at the nuclear periphery. Biochem. Soc. Trans. *39*, 1735–1741.

Brohawn, S.G., Partridge, J.R., Whittle, J.R., and Schwartz, T.U. (2009). The nuclear pore complex has entered the atomic age. Structure *17*, 1156–1168.

Burke, B., and Roux, K.J. (2009). Nuclei take a position: managing nuclear location. Dev. Cell *17*, 587–597.

Cronshaw, J.M., Krutchinsky, A.N., Zhang, W., Chait, B.T., and Matunis, M.J. (2002). Proteomic analysis of the mammalian nuclear pore complex. J. Cell Biol. *158*, 915–927.

Galy, V., Mattaj, I.W., and Askjaer, P. (2003). Caenorhabditis elegans nucleoporins Nup93 and Nup205 determine the limit of nuclear pore complex size exclusion in vivo. Mol. Biol. Cell *14*, 5104–5115.

Hoelz, A., Debler, E.W., and Blobel, G. (2011). The structure of the nuclear pore complex. Annu. Rev. Biochem. *80*, 613–643.

Mellad, J.A., Warren, D.T., and Shanahan, C.M. (2011). Nesprins LINC the nucleus and cytoskeleton. Curr. Opin. Cell Biol. *23*, 47–54.

Rout, M.P., Aitchison, J.D., Suprapto, A., Hjertaas, K., Zhao, Y., and Chait, B.T. (2000). The yeast nuclear pore complex: composition, architecture, and transport mechanism. J. Cell Biol. *148*, 635–651.

Starr, D.A., and Fridolfsson, H.N. (2010). Interactions between nuclei and the cytoskeleton are mediated by SUN-KASH nuclear-envelope bridges. Annu. Rev. Cell Dev. Biol. *26*, 421–444.

Worman, H.J. (2012). Nuclear lamins and laminopathies. J. Pathol. *226*, 316–325.

  DOI 10.1016/j.cell.2012.08.003